Issued June 30, 1908.

HAWAII AGRICULTURAL EXPERIMENT STATION.

J. G. SMITH, SPECIAL AGENT IN CHARGE.

BULLETIN No. 17.

HAWAIIAN HONEYS.

BY

D. L. VAN DINE,

ENTOMOLOGIST, HAWAII AGRICULTURAL EXPERIMENT STATION,

AND

ALICE R. THOMPSON,

ASSISTANT CHEMIST, HAWAII AGRICULTURAL EXPERIMENT STATION.

UNDER THE SUPERVISION OF

OFFICE OF EXPERIMENT STATIONS,

U. S. DEPARTMENT OF AGRICULTURE.

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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

JARED G. SMITH, *Special Agent in Charge.*
D. L. VAN DINE, *Entomologist.*
J. EDGAR HIGGINS, *Horticulturist.*
C. J. HUNN, *Assistant Horticulturist.*
F. G. KRAUSS, *In Charge of Rice Investigations.*
Q. Q. BRADFORD, *Assistant in Rubber Investigations.*
ALICE R. THOMPSON, *Assistant Chemist.*

Bul. 17

LETTER OF TRANSMITTAL.

HONOLULU, HAWAII, *March 16, 1908.*

SIR: I have the honor to submit herewith, and recommend for publication as Bulletin No. 17 of the Hawaii Agricultural Experiment Station, a paper on the source, characteristics, and composition of Hawaiian honeys, prepared jointly, under my direction, by the entomologist and assistant chemist of the station.

Respectfully,

JARED G. SMITH,
Special Agent in Charge.

DR. A. C. TRUE,
Director Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON, *Secretary of Agriculture.*

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HAWAIIAN HONEYS.

PART I. THE SOURCE AND CHARACTERISTICS OF HAWAIIAN HONEYS.

By D. L. Van Dine.

INTRODUCTION.

Several years ago the writer was informed by prominent bee keepers that Hawaiian honey in some instances was not favorably received in the mainland and the London market. In the spring of 1905 a detailed study was begun on the source and characteristics of Hawaiian honeys, the chemist of the station cooperating in a determination of their chemical composition. Comparisons with honeys that the market does accept as standard types indicate some justification for complaint, but do not justify the charges of adulteration made by some buyers. The investigations have progressed far enough to show that while one type of Hawaiian honey does depart widely from the present official definition of honey, it is from a source and of a character little understood up to the present time.

It is thought best to publish this phase of the bee-keeping investigations in advance of a general report on Hawaiian apiculture, as its bearing on the marketing of the Hawaiian product is all-important. The writer has collected fifty-four samples of Hawaiian honeys representing all the types of the Hawaiian product. In each instance the exact source has been determined. The samples have been taken from the bulk in the ripening tanks, and are therefore representative. In Part II the complete analyses of forty-nine of these samples, with a discussion of their composition, is given by Miss Alice R. Thompson, assistant chemist of this station.

This work has been carried on in cooperation with the leading concerns engaged in bee keeping in Hawaii, and the writer would here express his thanks to those who have given assistance and information, and would especially mention the help of Mr. E. C. Smith, manager of the Garden Island Honey Company, of Honolulu.

TYPES OF HAWAIIAN HONEYS.

Hawaiian honeys consist of two quite distinct types: (1) A floral product which compares very favorably with the official definition of honey and is derived mainly from the flowers of algeroba, and (2) a honeydew product very decidedly abnormal in its chemical composition. Between these two types, and partaking of some of the characteristics of each, are natural honeys that are the result of some of the bees in a hive visiting flowers where floral nectar is gathered and others visiting sugar cane where honeydew is collected. The nectar and the honeydew are deposited together in the comb, and the character of this product is determined by the relative proportions of the two collected and stored by the bees. So long as there is an abundance of flowers, the honey produced will be wholly of the first type, but as the supply of floral nectar decreases the bees visit the cane fields, where they collect honeydew, and when there is a dearth of flowers honeydew alone is collected. This condition results in natural combinations of the two types, which show every gradation from the pure floral product to that derived wholly from honeydew.

ALGEROBA HONEY.

The source of the floral product is mainly the flowers of algeroba, or the native "Keawe" (*Prosopis juliflora*). (Pl. I, fig. 1.) In the early days individual owners of bees selected locations mountainwards, near native forest trees, from some of which honey was produced. The apiaries rarely increased to above 50 colonies in number, and the product was consumed locally. It was not until the introduced algeroba had spread along the seacoast, forming an abundance of bee pasturage, with locations for apiaries easy of access, that the production of honey assumed commercial proportions. The principal apiaries to-day are situated along the coast of the islands of Oahu, Kauai, and Molokai, in the shelter of the algeroba forests. These locations are well stocked with bees (possibly in some cases overstocked), and the present production of algeroba honey is a little over 200 tons. Last year's (1906) total crop of honey amounted to 600 tons, and the remaining 400 tons was either a distinctly honeydew honey or honeydew honey and floral honey with decided honeydew characteristics.

As regards its chemical composition, the algeroba honey is by far the best that Hawaii produces on a commercial scale. The definition of honey, as found in Circular No. 19, Office of the Secretary, United States Department of Agriculture, is:

1. *Honey* is the nectar and saccharine exudations of plants gathered, modified, and stored in the comb by honeybees (*Apis mellifica* and *A. dorsata*); is levorotatory, contains not more than twenty-five (25) per cent of water, not more

FIG. 1.—APIARY UNDER ALGEROBA TREES.

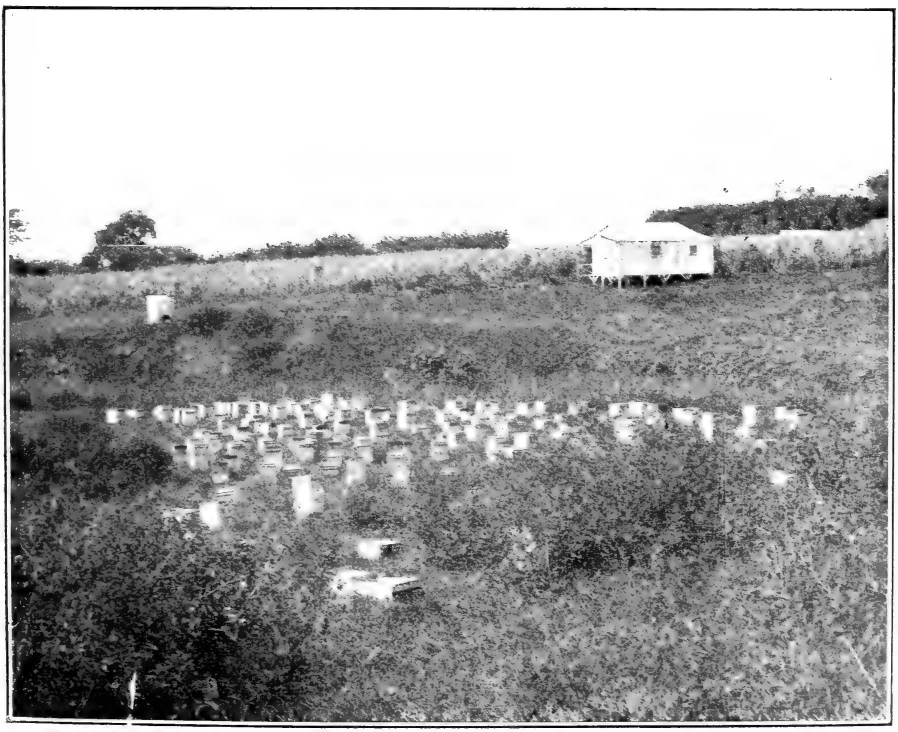

FIG. 2.—APIARY NEAR CANE FIELD.

than twenty-five hundredths (0.25) per cent of ash, and not more than eight (8) per cent of sucrose.

2. *Comb honey* is honey contained in the cells of comb.

3. *Extracted honey* is honey which has been separated from the uncrushed comb by centrifugal force or gravity.

4. *Strained honey* is honey removed from the crushed comb by straining or other means.

An analysis of a sample of pure algeroba honey showed the following composition:[a]

Analysis of algeroba honey.

Water	per cent	17.08
Ash	do	0.44
Sucrose (Clerget)	do	1.98
Reducing sugars (as dextrose)	do	80.32
Polarization direct		—17.7
Polarization indirect, at 32.8° C		—20.2

Only in the high ash content does the algeroba honey depart from the official standard.

Algeroba honey is nearly water white in color and solidifies soon after extraction. Its delicate flavor recommends the product for table use.

FLORAL HONEY OTHER THAN ALGEROBA.

To a greater or lesser degree, depending on location, bees in Hawaii derive honey from the nectar of the flowers of lantana, guava, oi (*Verbena bonariensis*), pili grass (*Heteropogon contortus*), rice, ilima (*Sida* spp.), palm trees, fruit trees, ohia lehua (*Metrosideros polymorpha*), and various other forest trees, ornamental vines and plants, weeds, and shrubs. The honey from these sources, however, is lost in the much larger amount derived from algeroba and honeydew when produced on a commercial scale. While the presence of this varying floral honey can not be detected by taste or color in the bulk of honey of the two types, it does influence the chemical composition. Some of these floral honeys, though comparatively small in amount, are of a higher grade as regards color and aroma than the algeroba honey. The ohia lehua honey is a beautiful amber color and of a very fine flavor, and as a table honey is equal to any mainland product. The ilima honey is of a bright golden color and the flavor is good. As the ohia lehua and other floral honeys, except the algeroba, are very limited in amount and as the algeroba forests are well stocked, honey-producing plants must be introduced in order to increase the floral product to any great extent.

[a] See sample No. 43, p. 15.

HONEYDEW HONEY.

The honeydew product comes mainly from a viscid saccharine secretion of the sugar-cane leaf-hopper (*Perkinsiella saccharidica*) and the sugar-cane aphis (*Aphis sacchari*) deposited on the surface of the leaves of the sugar cane. However, in Hawaii, as in other tropical countries, the plant lice, scale insects, and related families of insects are abundant, and some honeydew is to be found on plants in almost any locality. The increase in the production of Hawaiian honey of recent years corresponds with the advent of the introduced sugar-cane leaf-hopper into the cane fields, and the present extension of the business is in the vicinity of the immense areas of land given to cane culture.

Mention should be made of the fact that certain plants possess foliary or extra-floral nectaries which secrete honeydew.

While no great amount of this product is gathered and stored by honeybees in Hawaii, they have been observed locally collecting the honeydew from such glands on the hau tree (*Paritium tiliaceum*).

The amount of honeydew honey collected is in addition to the total amount available from the floral source, for it is only when the algeroba flower ceases that the bees seek the honeydew of the sugar-cane fields. The larger amount of honeydew is obtained from the young plant cane, for there the leaf-hoppers are more active. The flow of honeydew is limited by the maturity of the cane and the rains that wash the secretion from the leaves.

An analysis of honeydew honey elaborated entirely from the secretion of the sugar-cane leaf-hopper is as follows:[a]

Analysis of honeydew honey.

Water .... per cent..	15.12
Ash .... do....	2.04
Sucrose (Clerget) .... do....	7.2
Reducing sugars (as dextrose) .... do....	59.76
Polarization direct	+24.5
Polarization indirect, at 31.7° C	+15.3

A more detailed analysis of a duplicate sample of this honey made by C. A. Browne, of the Bureau of Chemistry, United States Department of Agriculture, agrees with the above analysis in all essential points. (See p. 17.)

Honeydew honey is noncrystalline and usually of a very dark color. The aroma is very similar to that of molasses and the taste insipid. The product is abnormally high in ash, the amount ranging from 1 to 2 per cent, and it has a decided right-handed polarization.

[a] See Part II, sample No. 17, p. 14.

NATURAL MIXTURES OF ALGEROBA HONEY AND HONEYDEW HONEY.

Aside from the typical white algeroba honey and the dark honeydew honey, there are intermediate natural honeys tending toward either the algeroba or honeydew type in proportion to the relative amounts of the two types collected and stored by the bees, as already explained (p. 8). Much of this honey though possessing the honeydew flavor and dark color resembles the algeroba honey in its chemical composition, and it departs from the present official standard only in its high ash content. This is explained by the fact that the characteristics of a comparatively small amount of the dark honeydew honey predominate over a larger amount of the white algeroba honey, since the latter lacks color and does not have a strong flavor. As already stated, of the 600 tons of honey produced in 1906, 200 tons were algeroba. A still smaller amount, probably not exceeding 100 tons, could be classed as a typical honeydew honey. The remaining 250 to 300 tons consisted of natural combinations of the two types, with an admixture in some instances of a dark floral honey derived in a limited amount from other nectar-producing plants.

With the exception of their crystalline properties, the bulk of the Hawaiian honeys can not be separated by their physical properties. The white algeroba and the dark honeydew are easily detected, but the large bulk of intermediate product can be separated only by chemical analysis. The exception noted is that any tendency toward immediate crystallization on the part of a honey indicates that the larger part of the mixture is algeroba and that the honey is optically levorotatory and, with the exception of the ash content, within the present standard. It can be stated that as a rule the greater the tendency toward crystallization the greater will be the left-handed polarization. However, some honeys with slight polarization to the left do not show indications of immediate crystallization, but do show decided tendencies toward crystallization after standing for some time.

MARKETING HAWAIIAN HONEY.

On account of its wide variation, Hawaiian honey can not be sold on sample. Polarization is necessary to determine whether or not the product is optically right or left handed.

The algeroba and other natural honeys produced in Hawaii which polarize to the left essentially come within the standard definition of honey, since they meet all the requirements, with the exception of the ash content. The honeydew honey and other natural Hawaiian honeys which polarize to the right should be designated by a modifying term, such as is included in the phrase "honeydew honey." Such

honey may further be described as a natural product containing no added glucose or other added sugars. It is a product gathered and stored by the honeybee and as such is unadulterated.

The present official definition of honey is based on examinations of types of well-known floral honeys and represents honey sold and used for table consumption. For this trade, color and aroma are all-important. On the other hand, more than 50 per cent of the honey produced in the United States is used in the baking and confectionery trade. For this trade, color and aroma are of less importance. The value of honey for baking purposes depends on its baking and boiling properties. Honey is used in bakestuffs and candies for the reason that it imparts a texture and degree of moisture that other sugars will not give. Buyers assert that Hawaiian honeydew honey has better baking and boiling properties than the higher grade algeroba honey, and one local company received from one-half cent to 1 cent more per pound for their honeydew honey than they did for the algeroba product of the 1906 crop.

PART II. CHEMICAL COMPOSITION OF HAWAIIAN HONEYS.

By Alice R. Thompson.

During 1906 forty-nine samples of Hawaiian honeys of known origin were collected by the station entomologist and analyzed by the writer. The honeys consisted of two types, a floral and a honeydew product. As explained in Part I of this bulletin (p. 9), the floral honey is derived mainly from the flowers of algeroba and the honeydew is chiefly a secretion of certain insects in the sugar-cane fields. The composition of these two types and the natural mixtures of them were determined and compared. The source, general character, and composition of the honeys examined are shown in the table on the next page.

ALGEROBA HONEY.

The composition of algeroba honey, as determined in the laboratory, resembles that of a normal honey with the exception of its high ash content. The ash varies between 0.44 and 0.59 per cent, while according to the present official standard a pure honey should not exceed 0.25 per cent.

An analysis of a sample of algeroba honey (sample No. 43) gave 0.446 per cent of ash, containing potash 0.258, phosphoric acid 0.008, calcium 0.013, magnesia 0.004, alumina 0.003, and chlorin 0.003 per cent.

As is seen from the analysis reported on page 9, this honey meets the requirements of the standard with the exception of the ash. Its direct polarization is to the left; its indirect polarization deviates only a few degrees further to the left; at 87° C. its polarization is but slightly to the right; the sucrose content is low and the percentage of reducing sugar is high. The acidity (0.064 per cent, calculated as formic acid) was found to be low. On addition of methyl alcohol to the honey the precipitate formed was but 0.23 per cent. In another honey of the same type whose direct polarization was —18.4 the precipitate amounted to 0.195 per cent. The precipitate was slightly soluble in water and the solution of the soluble part, made up to

Source and composition of Hawaiian honey.

No.	Representing.	Date of extraction.[a]	Locality.	Source.	Water.	Ash.	Sucrose (Clerget).	Reducing sugars.[b]	Polarization. Direct.	Polarization. Indirect.	Temperature.
	Tons.				*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Deg.*	*Deg.*	*Deg. C.*
1	3	Jan. 2	Kipapa Gulch, Oahu	Honeydew and weeds (lantana, *Waltheria americana, Heteropogon contortus*, and *Verbena bonariensis*).	16.14	1.27	4.1	57.72	+16.2	+11.0	30.0
2	2½	Feb. 20	Pearl City, Oahu	Honeydew and *Malvastrum tricuspidatum*	16.14	1.64	2.1	55.92	+19.1	+14.3	30.0
3	1¾	Feb. 26	Waipio, Oahu	do	15.49	1.68	5.3	59.28	+20.7	+13.9	32.0
4	3	Mar. 8	Kipapa Gulch, Oahu	Honeydew and weeds (lantana, guava, *Waltheria americana, Heteropogon contortus*, and *Verbena bonariensis*).	16.34	.99	3.9	64.61	+ 8.0	+ 3.0	30.0
5	1	Mar. 19	Pearl City, Oahu	Honeydew honey from old brood cells extracted in sun machine	16.15	1.66	5.2	58.43	+17.8	+11.2	32.0
6	¾	Mar. 28	Kalaowao, Oahu	Honeydew and weeds	16.15	1.26	3.2	60.12	+14.6	+10.5	32.0
7	2	Apr. 9	Aiea, Oahu	do	15.68	1.62	3.2	59.96	+14.4	+10.3	32.5
8	1	Apr. 23	Pearl City, Oahu	do	15.92	2.10	4.2	58.20	+19.2	+13.8	33.0
9	2	May 7	do	Honeydew and rice	16.43	1.12	3.9	60.72	+ 7.8	+ 2.8	32.5
10	1	May 21	do	do	16.62	1.29	4.1	59.32	+ 8.7	+ 3.5	32.5
11	1¾	June 4	do	Algeroba and honeydew	17.92	.69	2.3	77.28	−14.3	−17.3	32.3
12	¾	June 12	Kalaowao, Oahu	do	17.46	1.12	2.3	67.28	+ 4.0	− 1.0	32.2
13	1½	June 18	Aiea, Oahu	do	17.08	1.18	2.2	67.52	+ 3.8	− 1.0	31.6
14	¾	June 25	Waipio, Oahu	Algeroba	18.71	.58	2.4	76.64	−18.3	−21.4	31.5
15	2	July 11	Pearl City, Oahu	Honeydew and algeroba	17.16	1.06	2.7	65.56	− 0.3	− 3.8	32.7
16	1⅔	July 25	Waipio, Oahu	do	15.82	1.33	4.5	63.08	+ 8.9	+ 3.2	33.0
17	5 lbs.	Sept. 18	Pearl City, Oahu	Honeydew	15.12	2.04	7.2	59.76	+24.5	+15.3	31.7
18	1	Mar. 6	Pokii, Kauai	Honeydew and weeds	15.31	2.02	4.3	61.28	+20.9	+15.4	30.6
19	½	Apr. 4	Hanapepe, Kauai	do	16.05	1.91	4.4	60.22	+15.8	+10.2	32.0
20	1½	Apr. 10	Mana, Kauai	do	16.05	1.82	4.8	60.40	+20.9	+14.8	33.3
21	1⅕	Apr. 17	Kekaha, Kauai	Honeydew and algeroba	15.59	1.82	4.1	61.09	+17.5	+12.2	32.5
22	2½	Apr. 23	Waimea, Kauai	Honeydew and weeds	16.43	1.21	3.4	63.36	+11.4	+ 7.0	32.0
23	1½	May 12	Limaloa, Kauai	Honeydew and algeroba	15.82	1.62	3.1	61.28	+16.9	+12.9	33.8
24	1	May 16	Waimea, Kauai	do	16.94	1.50	3.3	69.40	+ 0.1	− 3.2	32.7
25	1½	May 22	Pokii, Kauai	do	15.82	1.61	4.1	63.08	+10.6	+ 5.3	32.0
26	1¾	May 25	Mana, Kauai	Honeydew, *Heteropogon contortus*, algeroba, and *Ipomœa pes-capræ.*	15.31	1.78	6.3	60.92	+18.5	+10.5	33.0
27	3	May 27	Waimea, Kauai	Algeroba and honeydew	17.08	.79	1.6	72.96	−12.3	−14.4	32.2
28	1½	May 31	Kekaha, Kauai	Algeroba, weeds, and honeydew	17.55	.72	2.2	72.36	− 8.7	−11.5	33.6
29	2	June 2	Hanapepe, Kauai	Honeydew and algeroba	16.62	1.26	3.9	63.08	+ 9.0	+ 4.0	34.0
30	2	June 14	Mahinauli, Kauai	do	17.55	.75	2.1	70.79	− 6.3	− 8.9	33.5
31	1½	June 25	Limaloa, Kauai	Honeydew, algeroba, and weeds	16.24	1.65	4.8	64.60	+12.4	+ 6.3	32.8
32	1⅕	June 27	Waimea, Kauai	Algeroba and honeydew	16.94	1.11	3.7	66.16	+ 0.5	− 4.2	33.2
33	1⅓	June 20	Pokii, Kauai	Honeydew, algeroba, and weeds	17.17	1.58	3.8	63.04	+ 7.6	+ 2.8	32.7
34	2⅔	July 7	Mana, Kauai	Honeydew	15.82	1.74	5.6	59.28	+20.7	+13.6	32.7
35	2½	July 10	Hanapepe, Kauai	Honeydew and algeroba	16.34	1.37	5.7	63.36	+10.8	+ 3.5	32.4
36	1⅓	July 13	Kekaha, Kauai	Honeydew, algeroba, and weeds	16.05	1.48	4.9	64.92	+ 9.0	+ 2.7	32.6
37	2⅔	July 16	Waimea, Kauai	Honeydew and algeroba	15.82	1.41	3.9	66.08	+ 5.9	+ .9	33.5

42	([c])	July —	Mount View, Hawaii	Honeydew and forest trees	18.94	.98	3.3	63.12	+ 9.7	+ 5.5	31.8
43	4½	May 29	Kaunakakai, Molokai	Algeroba	17.08	.44	1.98	80.32	−17.7	−20.2	32.8
44	10	July —	Kolo, Molokai	do	19.31	.53	2.4	74.28	−19.7	−22.7	33.0
45	4	July —	do	do	20.43	.53	2.1	78.28	−19.1	−21.7	32.2
47	2½	July —	Hoolehua, Molokai	Algeroba and wiliwili (*Erythrina monosperma*)	18.01	.59	1.8	73.48	−19.4	−21.7	33.6
48	([c])	Oct. 1	Kaulapuu, Molokai	*Eucalyptus globulus* and weeds	18.01	.58	3.1	73.52	−16.8	−20.7	32.6
49	([c])	Oct. 8	Poholua, Molokai	Ohia lehua (*Metrosideros polymorpha*)	20.72	.33	1.4	70.56	−11.6	−13.4	33.5
50	([c])	Oct. 21	Tantalus, Honolulu	*Verbena bonariensis, Ipomœa* sp., *Thevetia nereifolia, Malvastrum tricuspidatum,* lantana, and guava.	18.72	.49	3.1	72.00	−15.4	−19.3	33.7
51	3	Sept. 13	Kipapa, Oahu	Honeydew and weeds	16.15	1.42	3.9	62.52	+11.3	+ 6.3	32.1
52	1½	Sept. 10	Aiea, Oahu	Honeydew and algeroba	15.91	1.85	4.0	60.02	+16.2	+11.1	32.6
53	1¾	Sept. 17	Pearl City, Oahu	do	16.33	1.77	5.3	58.92	+19.2	+12.4	33.3
54	1¼	Oct. 15	Kalaowao, Oahu	Honeydew and rice	16.24	1.82	4.4	61.32	+17.7	+12.1	32.8

[a] No. 5 taken from solar extractor, all others from centrifugal. [b] Determined as dextrose. [c] The product of a single colony.

50 cubic centimeters, polarized but 0.2 degree to the right. Twenty grams of the honey was dissolved in 20 cubic centimeters of water, made up to 250 cubic centimeters with methyl alcohol, and allowed to stand several days; the precipitate was washed, dried, and weighed, and results obtained as given above. The honey filtrate, from which the alcohol was removed by evaporation, made up to its original volume, gave a polarization of —4.80 and, after inversion, of —6.6 at 31.7° C.

Twenty grams of honey was diluted to 250 cubic centimeters with absolute ethyl alcohol (according to the method of König and Karsch [a]) and allowed to stand several days. The precipitate formed by this alcohol amounted to 0.194 per cent, about equal to that formed by methyl alcohol. The filtrate, from which the alcohol had been removed, made up to the original concentration, gave a polarization of —5.3 and, after inversion, —6.8 at a temperature of 30.3° C. As will be shown later, the two kinds of alcohol have quite different effects upon the honeydew honey.

HONEYDEW HONEY.

The analysis of many samples of honeydew honey shows it to be abnormal. A number of samples were examined. Nos. 1 and 17 were dark in color and derived mostly from honeydew. No. 13 was a sample of honey containing a greater proportion of floral honey. The results of the analyses were as follows:

Analyses of honeydew honeys.

	Water.	Ash.	Sucrose (Clerget).	Reducing sugars.	Acidity.	Dextrin.[a]	Nitrogen.	Polarization.		
								Direct.	Indirect.	At 87° C.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Degrees.*	*Degrees.*	
Sample No. 1	16.14	1.27	4.1	57.72	([b])	([b])	0.31	+16.2	[c] +11.0	+33.0
Sample No. 17	15.12	2.04	7.2	59.76	0.172	0.339	([b])	+24.5	[d] +15.3	+36.0
Sample No. 13	17.08	1.19	2.2	67.52	([b])	([b])	([b])	+ 3.8	[e] − 1.0	+24.0

[a] Dextrin was precipitated by methyl alcohol.
[b] Not determined.
[c] At 30° C.
[d] At 31.7° C.
[e] At 31.6° C.

An inspection of these analyses shows that the honey differs greatly from the present official standard.

A more detailed analysis of sample No. 17, a typical sample of honeydew honey, made in the Bureau of Chemistry, U. S. Department of Agriculture, gave the following results: [b]

[a] Leffmann and Beam. Food Analysis. Philadelphia, 1901, p. 138.

[b] Letter of Dr. H. W. Wiley, December 1, 1906.

Detailed analysis of honeydew honey (No. 17).

Water --per cent--	16.87
Total solids --------------------------------------do----	83.13
Ash ---do----	1.20
Organic solids-------------------------------------do----	81.93
Free acid as formic--------------------------------do----	.18
Reducing sugar as invert---------------------------do----	61.63
Reducing sugar after inversion---------------------do----	68.43
Sucrose (68.43—61.63) × 0.95=----------------------do----	6.46
Organic solids not sugar (dextrin, gums, acids, etc.) 81.93 —(61.63 + 6.46)=--------------------per cent--	13.84
Polarization, immediate--------------------------------	+24.90
Polarization, after standing 12 hours (22°—birotation)---	+17.30
Invert polarization (22°)------------------------------	+13.70
Polarization 86°---------------------------------------	+36.0

Moisture.—The water content of the honeydew honey is lower than that of the algeroba honey, although it is not lower than that common to normal honeys.

Ash.—The ash content is very high, ranging from three to six times the amount found in normal honeys, the latter seldom exceeding 0.3 per cent. The ash was determined by charring a weighed amount of honeys, leaching out the soluble salts, and igniting the residue to whiteness, then uniting the residue and salts, and on gentle ignition weighing the whole as ash. The analysis of the ash is as follows:

Analysis of ash of honeydew honey.

	Sample No. 1.	Sample No. 17.
	Per cent of honey.	*Per cent of honey.*
Ash------------------	1.270	2.039
Potassium oxid------	.893	1.148
Phosphoric acid------	.158	.165
Calcium oxid--------	.009	Not determined.
Magnesium oxid------	.018	Do.
Sulphurous acid------	.021	Do.
Sodium chlorid-------	.110	Do.

The ash was strongly alkaline in reaction, in which respect it resembled the ash of a normal honey.

The potash (K_2O) and phosphoric acid (P_2O_5) are high and seem to be peculiar to the honeydew honey. The potash content is much higher than in algeroba honey.

Polarization.—One of the most important features of honeydew honey is its high right-handed polarization, which, in a honey, generally indicates adulteration with sucrose or glucose. By the polarization of the inverted honey this honey can be easily distinguished from honey adulterated with sucrose, since the deviation to the left after

inversion is small, while in honey adulterated with sucrose the deviation after inversion to the left would be very great.

On raising the temperature of the inverted solution to 87° C. the polarization is far to the right, exceeding that of the algeroba honey, which under such conditions polarizes but 1 or 2 degrees to the right. The presence of a highly dextrorotatory substance is indicated. The difference between honeydew and algeroba honey in this respect is shown in the following table:

Indirect polarization of honeydew and algeroba honey at 87° C.

[Readings on Schmidt and Haensch scale.]

Sample.	Honeydew honey.	Algeroba honey.
	Degrees.	*Degrees.*
1	+33.0	
17	+36.0	
13	+24.0	
50		+2.2
43		+1.6
14		+1.2

Fermentation.—Fermentation of the honey was obtained by weighing out 25 grams of the honey, dissolving it in water, neutralizing the free acid with potassium hydrate, and acidifying with tartaric acid, and adding a little potassium fluorid; 25 cubic centimeters of brewer's yeast was added, the volume made up to 200 cubic centimeters, and the fermentation carried on seven days. The volume was then made up to 250 cubic centimeters, clarifying with aluminum cream, and filtered. Two hundred cubic centimeters was evaporated to remove alcohol, and the residue made up to a volume of 100 cubic centimeters.

In these experiments the free formic acid was neutralized to prevent its antiseptic action, but the formates so formed may also act as antiseptics.

Brewer's yeast was also used, as, according to Raumer,[a] compressed yeast completely destroys the dextrin in honey so that the fermentation residue then often gives a neutral polarization. In many honeys fermented by beer or wine yeast, the fermentation residue causes a right-handed polarization.

The fermentation residues of the honeydew honeys (samples 17, 1, and 2) under consideration, are rather strongly dextrorotatory, while those of the algeroba honey (sample 14) and other floral honeys are levorotatory, as shown in the table following.

[a] Ztschr. Angew. Chem., 1890, p. 421.

Polarization of honeys after fermentation.

[Concentration, 20 grams honey in 100 cubic centimeters.]

Sample	17.	1.	2.	27.	14.
Polarization (degrees)	+30.4	+28.6	+24.0	+11	+6

When the fermentation residue of a honey gives a right-handed rotation it is generally considered to be an adulterated honey. However, normal honeys have been found whose unfermentable residues give a right-handed polarization when the beer or wine yeast has been used. Raumer[a] found that a 10 per cent fermentation residue of a normal honey might give a dextrorotation of value of +11.86 to +13.77 (Laurent). So, although the honeydew honey gives after fermentation a right-handed polarization, it should not, therefore, be classed as a glucose honey. However, by the fermentation method, it is certainly not to be distinguished from a glucose honey.

The unfermentable carbohydrates determined as dextrose found in the fermentation residue were as follows:

Unfermented carbohydrates calculated as dextrose in fermentation residues of different honeys.

Sample.	Before inversion.	After inversion.	Difference.[b]
	Per cent.	*Per cent.*	*Per cent.*
17	7.25	17.47	10.22
1	7.49	18.94	11.45
2	6.57	16.14	10.57
27	2.67	7.98	5.31
14	1.02	3.91	2.89

[b] Difference due to dextrinous matter.

The results show that the honeys rotating to the right before fermentation contain the greatest amounts of unfermentable carbohydrates.

Precipitation with alcohol.—Methyl alcohol causes in honeydew honey a somewhat stringy, but not gummy, precipitate, part of which does not dissolve in water.

Twenty grams of honey, samples 17 and 3, were made up to 250 cubic centimeters with methyl alcohol and allowed to stand. The precipitates obtained amounted to 0.339 per cent and 0.27 per cent, respectively, and were optically inactive.

One hundred cubic centimeters of the honey filtrate (sample No. 3) were placed on the water bath to remove alcohol and made up again

[a] Ztschr. Angew. Chem., 1889, p. 608.

to 100 cubic centimeters. The direct polarization was +6.8°, and after inversion +5.2° at 30.5° C.

According to Bechmann,[a] methyl alcohol precipitates in natural honey only a small amount of carbohydrates, while in glucose honey it precipitates large amounts of the starch dextrin, so that a natural honey can thus be distinguished from an adulterated honey. By this method honeydew honey can be distinguished from one adulterated with glucose.

Also, most honey adulterated with glucose gives a red color when treated with iodin in potassium iodid solution, while honeydew honeys do not give this reaction. This test may also serve to distinguish honeydew honeys from glucose honeys.

Absolute alcohol precipitates in the honey a large amount of gummy matter which is strongly dextrorotatory. Twenty grams of honey (sample No. 3) was diluted to 20 cubic centimeters with water and absolute alcohol carefully added, a little at a time, and well mixed by shaking until the volume was completed to 250 cubic centimeters. On standing several days the alcohol solution was filtered off, and the gummy mass washed with alcohol and dissolved in hot water, an aliquot part dried and weighed, and any reducing sugar determined and deducted from the weight. The precipitate amounted to 9.93 per cent, which is about equal to the percentage of dextrinous matter determined in the fermentation residue as dextrose.

The alcohol was removed from 100 cubic centimeters of the honey filtrate and the residue clarified with aluminum cream and made up to 100 cubic centimeters and filtered. The solution gave a polarization of —0.5°, and after inversion, of —1.5° at a temperature of 28.8° C. The filtrate from sample No. 39, treated as above, gave a direct polarization of —0.8°.

This latter method was recommended by Dr. H. W. Wiley,[b] as according to König and Karsch,[c] the levorotation of a honey solution from which the dextrinous bodies have been separated by absolute alcohol shows a pure dextrorotatory honey and distinguishes it from a glucose honey.

Sucrose.—The sucrose content in the honeydew honeys is somewhat high, but 8 per cent sucrose has been found in floral honeys. According to König,[d] the content has even been found to be as high as 12 per cent in pure honey.

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[a] Leffmann and Beam. Food Analysis. Philadelphia, 1901, p. 135.

[b] Letter of Dr. H. W. Wiley, December 1, 1906.

[c] Ztschr. Analyt. Chem., 34 (1895), p. 1.

[d] Untersuchung landwirtschaftlich und gewerblich wichtiger Stoffe. Berlin, 1891, 1. ed., p. 463; 1906, 3. ed., p. 589.

Reducing sugars.—The reducing sugars determined as dextrose in pure honey according to Leffmann and Beam vary from 60 to 75 per cent. In the more distinct types of honeydew honey the reducing sugar content is somewhat below 60 per cent.

Acidity.—The acidity of the honeydew honey is high, amounting to 0.172 per cent as formic acid, this being about three times the amount found in the algeroba honey.

Nitrogen.—The nitrogen content of both the algeroba and the honeydew honey is low, sample No. 1 containing 0.05 per cent and sample No. 14, 0.04 per cent.

The honeydew honey obtained from the Hawaiian sugar-cane fields may be compared to that of the pine forests as examined by Dr. H. W. Wiley. According to Wiley,[a] the honeydew honey of America is characterized by right-handed polarization at ordinary temperatures, deficiency of invert sugar, and high ash content. Hawaiian honeydew honeys agree in the high ash content and right-handed polarization.

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[a] Jour. Amer. Chem. Soc., 14 (1892), p. 351.

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